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Seasonal Variation Affecting Sex Expression of Coba (*Zizania latifolia* Turcz.)[1]

Tsung-Dao Liou[2]

Abstract : Coba (*Zizania latifolia* Turcz.) cv. Green Shell flowers continuously from early May to mid-November in southern Taiwan. It is monoecious, which male and female flowers occur on the same inflorescence. Each inflorescence consists of many spikelets and forms a large panicle. Most of male flowers distributed at the lower portion of spikelets in the inflorescence, while the female flowers distributed oppositively. The length of inflorescence, inflorescence node, and lateral inflorescence ; no. of lateral inflorescences, total flowers, deformed flowers, male flowers vary with the flowering month. The length of flower inflorescence, inflorescence node and lateral inflorescence do not vary from May to September, but decrease after October. The no. of lateral inflorecence, total flowers, deformed flowers, male flowers and female flowers increase from May, reach a maximum in August or September, and then decrease. The ratio of male/female flowers is highest (at 4 : 1) in May and then gradually decreases to 2 : 1 in July and August, to 1 : 1 in October, and then sharply decreases in November with veryfew (if any) male flowers.

Coba is a perennially ratooned aquatic vegetable , tolerant to heat and flooding. It is popularly cultivated in tropical and sub-tropical swamp areas and paddies [19,49,56]. Farmers continue to plant young coba seedlings from late November to early March of next year [27,30]. Young seedlings did not elongate but malformed swollen galls when infected by *Ustilago esculenta* P. Henn. on the base parts of 4 or 5 node of coba stem. This edible gall is called "Kah- Peh-sung" (local name) or "water shoot" [10,17,18,32,33,50,57,58,59] and is a very important summer vegetable during monsoons of Taiwan [26,31,51]. On the contrary, the stem has no gall formation and continue to elongate and flower if plant was not infected by fungus [29,57]. Liou (1977) showed the cultivar Green Shell of coba flower continuously from early June to late October in southern Taiwan. The plant is monoecious, and the inflorescence is one large typed panicle or compound raceme and

1. Contribution No. 1081 from the Taiwan Agricultural Research Institute.

2. Assistant Horticulturist, Fengshan Tropical Horticultural Experiment Station, TARI, Fengshan City , Kaohsiung Hsien , Taiwan 830, ROC.

consists of many lateral inflorescence, secondary lateral inflorescence and spikelets. Most of female flowers are located in upper parts of inflorescence. Whereas, most of male flowers are concentrated in lower parts. There is almost equal number of male and female flowers (the ratio of male flowers to female flowers about 1 : 1) in the middle part of inflorescence when flowers in July [29]. The variation of the flower morphology, number of male and female flowers and changes of sex expression on the other months still unclear. This present continued on previous research [29] for studing the seasonal variation in sex expression of coba under natural conditions. This information may offer to the people who are interested to the coba researches.

Material and Methods

The most popular cultivars of coba, cv. Green Shell was used. The young coba seedlings were planted in the experimental farm of Fengshan Tropical Horticultural Experiment Station, TARI, on March 15, 1978 and March 11, 1979, respectively. One hundred of young coba seedlings were planted in each experiment. The growing seedlings were managed in accordance with the general coba culture methods. Six of normal flowered inflorescence were sampled to investigate plant height of flowering tillers, length of flower inflorescence, length of lateral inflorescence, no. of lateral inflorescence, length of inflorescence node, no. of inflorescence node, no. of flowers per inflorescence, no. of deformed flowers per inflorescence, no. of male flowers per inflorescence, no. of female flowers per inflorescence and ratio of male to female flowers at one week interval for two weeks in the months of May and November, and for four two weeks in the other months. There were 144 inflorescences of each year were investigated.

Results

I. Effects of seasonal variation on the inflorescence morphology of coba

1. Effects of seasonal variation on the plant height of flowering tillers of coba.

Young coba tillers continued to grow up from the crown of young coba seedlings. When the base nodes of those young tillers were infected by *Ustilago esculenta* P. Henn, the stem of those young tillers malformed and swolled and formed an edible gall. On the contrary, if the stem node of the tillers were not infected to the fungus, the stem continued to elongate and flower [28,29,32,33,50,57,58,59]. The tillering pattern of coba were same as sugar cane. All the tillers on the same crown (plant) do not come up at the same time, but grow up from the crown continuously. This is the reason why the plant height of flowering tillers appeared a great variation at the flowering time of the inflorescences. Figure 1 shows the plant height of flowering tillers appeared significant difference under different flowering seasons. The plant height of flowering tillers in May was 160-180 cm, then gradually increased and revealed the highest of 190-210 cm in July and August, and then gradually decreased to the reach lowest of 140 cm in November.

2. Effects of seasonal variation on the length of inflorescence of coba

Figure 2 shows the length of coba inflorescence differed with appeared the seasonal

variation. Although, the length of inflorescence did not differ in May to September, but it appears to decrease after September. The length of inflorescence flowered in May was about 70 cm, then reached to the longest of 75-80 cm in July and August, then decreased the shortest of 25-30 cm in November.

3. Effect of seasonal variation to the length of node and lateral inflorescence of coba

Figure 3 shows the length of node of inflorescence did not vary when plants flowered from May to September, but decreased after October. The length of node of inflorescence was about 4 cm in May and shortened to about 1.5 cm in November. The variation of lateral inflorescence was the same tendency of the node length. The length of lateral inflorescence also did not vary from May to September, but decreased after October. The length was about 11-13 cm when flowered from May to September then decreased sharply to only about 7 cm in November.

4. Effect of seasonal variation to the no. of node and lateral inflorescence of coba

Figure 4 shows the no. of node of inflorescence (18-20) reached to the maximum in July and August, but did not vary with other months. The no. of lateral inflorescence was about 40 in May, then reached to the maximum of about 55-60 in July and August, and 40 in November.

II. Effect of seasonal variation to the distribution of male and female flowers on the inflorescence of coba

The distribution of male and female flowers on the inflorescence varied with different months. Figure 5 and 6 show the distribution of male and female flowers on inflorescence which appeared to have a regular tendency from May to September, except October and November. Most of male flowers concentrated in lower parts of inflorescence and female in upper parts. The ratio of male/female flowers decreased when the inflorescence node increased. There was almost equal number of male and female flowers in the middle part of inflorescence. The male and female flowers located on the node position of the inflorescence also differed with different months. The location of male and female flowers on the inflorescence and the ratio of male to female flowers on the node sequence of inflorescence had a regularly tendency from May to September. The ratio of male/female flowers on the node sequence of inflorescence derceased as the node sequence increased from May to September, but the ratio decreased after October. The ratio of male/female flowers about 1 : 1 on the node sequence of 4-5 node when it flowered in October and with only very few (if any) male flowers when the plants flowered in November.

III. Effect of seasonal variation on the no. of flowers and sex expression of coba

Coba is monoecious aquatic plant. The male, female and deformed flowers are distributed on the same inflorescence. The total no. of flowers per panicle varied with different months. Figure 7 shows that 1,500-1,600 flowers per panicle (inflorescence) were formed in May and then reached to the maximum of 2,400-2,600 flowers per panicle during July, August and September, but decreased in October and November to about 1,000 and 250-300 flowers per panicle respectively.

The no. of deformed flowers also varied with different months. The no. of deformed

flowers per panicle was about 110-160 flowers in May, and reached to the maximum of 120-180 during June, July and August, but there was no great difference during June, July and August as compared with May and its decreased after September and reached to the minimum of 60 in November.

The no. of male, female flowers and the ratio of male to female flowers also varied with different months. The no. of male flowers per panicle were 1,000-1,200 flowers in May, and reached to the maximum of 1,400-1,600 in July and August. The no. of female flowers per panicle was about 300 flowers in May and reached to the maximum of 700-900 in July, August and September. The ratio of male to female flowers shows the highest at 4 : 1 in May and then decreased to 2 : 1 in July and August. The no. of male flowers decreased after September and reached 400-500 flowers per panicle in October. On the same time, the female flowers also decreased to about 500 flowers per panicle in October with ratio of about 1 : 1, and only very few (if any) male flowers on the panicle in November.

The percentage of deformed flowers, male flowers and female flowers on panicles also shows varied during different months. Figure 8 shows only 10% of deformed flowers without much variation during flowering months except 20% in November. There is 70-75% of male flowers on the panicle which is the highest proportion of male flowers in May and then decreased. In October, there is 40% male flowers and in November only very few male flowers produced. There are very low percentage of female flowers in the early stage then gradually increased with time of flowering. Only 20% of female flowers on the panicle when flowered in May and then increased to 40% in September and reached to the maximum of 80% in November.

Discussion

The change of nodal sequence, sex expression and the ratio of staminate to pistillate flowers may be modified by hereditary factors, environmental factors or interaction of hereditary factors and environmental factors[13]. Currence (1932) has found that during the life of a cucumber plant there is a gradual change from staminate to pistillate condition. This change is related to the nodal sequence ; the lower nodes being predominantly staminate, and the upper nodes predominantly pistillate. Shifriss and Galun (1956) indicated that the lower the node number of the first pistillate flower, the higher the female tendency in the monoecious varieties of cucumber[48]. In this investigation we found that the distribution and nodal sequence of male and female flowers on the inflorescence of coba changes with time (Figure 5 and 6). The changes of nodal sequence of male and female flowers on the inflorescence and sex expression of coba were similar to the cucumber[7,48]. The changes of sex tendency may be affected by length of day, temperature, light intensity, and light quality or other environmental factors. However, what are the major factors which affect the variation of male and female flowers on the nodal sequence and sex expression in the inflorescence of coba need further studies.

Rosa (1928) indicated that the ratio of staminate to pistillate flowers of cucumber

varies greatly with different environmental conditions[42]. Edmond (1930) also indicated that sex expression of cucumber varies greatly due to seasonal variation and the ratio of opened staminate flowers to pistillate varied from 51 : 1 to 21 : 1[9]. In this experiment, we found that the ratio of staminate to pistillate flowers of coba also varies greatly due to seasonal variation and the ratio of opened staminate flowers to pistillate varied from about 4 : 1 in May to about 1 : 1 in October and very few male flowers produced in November (Figure 7). On the changes of sex expression and sex ratio, Tiedjens (1928) indicated that nitrogen level may modify the sex expression and sex ratio of flowered cucumber plants. He indicated that high levels of nitrogen appear to promote male sex expression, whereas low levels favor female expression[54]. This fact has also been demonstrated in hemp and spinach[46,52,53]. However, how about of the nitorgen effect of sex expression and sex ratio of coba still unclear and need further studies.

Temperature and day length also influence on the sex expression of flowering plants. Tiedjens (1928) indicated that the reduction of light materially increases the number of pistillate flowers and decreases staminate flowers of the cucumber[54]. Hall (1949) was unable to alter flower ratio in the gherkin with different photoperiod ;[14] however, Nitsch et al (1952) later showed that short days promoted pistillate flower development in gherkin and squash while long days favored male expression[38]. Short day treatment has also been shown to cause a shift toward female sex expression in hemp, Japanese hop (*Humulus japonicus*, Sieb & Zucc.), maize, regweed (*Ambrosia elatior* L.) and cocklebur[18,36,44,45,57]. These are short day species with the exception of maize in which flowering is accelerated by short day treatment[41]. Conversely, in spinach, a long day plant, female sex expression is promoted by long days[52]. Heslop-Harrison (1957) has suggested that short days, low temperature, and high nitrogen levels may promote female sex expression of the hemp by increasing auxin concentration[16]. Brantley and Warren (1960) also indicated that medium and high nitrogen levels, and long days increased the number of staminate and perfect flowers as well as the proportion of perfect flowers in the muskmelon[4]. Atsmon and Galun (1962) indicated that the first nodal sequence of cucumber pistillate flowers decreased under high nitrogen levels and long day conditions[2]. It is clearly proved that the sex expression and ratio of staminate to pistillate flowers of plants are greatly influenced by temperature and day length. In this experiment, we also found that the number of male, female flowers and the ratio of staminate to pistillate flowers in the inflorescence of coba varies greatly during different flowering months have been mentioned (Figure 7). The clear variation of sex expression and sex ratio of coba in this experiment may be influenced by the changes of temperature and day length during the growth of coba. Figure 9 shows that normal temperature changes on the island are rising after April and reaches to maximum in June, July and August and decreases after September. Temperature in November is almost the same as March. Tendency of the changes of day length is almost the same as temperature. The month of May, June, July and August is considered to be a long day condition on the island and the day length shortened after September. The variation of male, female flowers number and ratio of stami-

nate to pistillate flowers of coba has the same tendency as changes of temperature and day length under different months. The results of this experiment and previous researches strongly indicated that the changes of sex expression and sex ratio of coba were deeply influenced by the variation of temperature and day length. But what is the critical point of these environmental factors need further studies.

Auxins or chemicals may also influenced sex expression of plants. Promotive effects of auxin on flowering have been reported in both long and short day species [8,24,25,35]. In contrast, inhibitions have been observed in may cases [22,24]. Laibach and Kribben (1950) proved a direct effect of auxin on sex expression in cucumber. Treatment with naphthaleneacetic acid increased the proportion as well as the total number of pistillate flowers [21]. Nitsch et al (1952) lowered the node at which the first pistillate flower of *Cucurbita pepo* L. appeared from the 20th to the 9th node with auxin applications [38]. Heslop-Harrison (1956) obtained similar results in hemp as pistillate flowers were formed on genetically male plants in sites normally occupied by staminate flowers [15]. Recently, Rudich, et al (1970), Lee and Janick (1978) indicated that the staminate flower formation of monoecious and andromonoecious lines of cucumber was decreased when treated with ethephon [23,43]. Byers et al (1972) reported on the use of 5-methyl-7-chloro-5-ethoxycarbonylmethoxy-2, 1, 3 benzothidiazole(MCEB)to maintain gynoecious muskmelon [6]. Anais (1971), Frankel and Galun (1977), Kubicki (1969) and Peterson (1963) have been tried without success in inducing perfect flowers on gynoecious lines cucumber by use of gibberellin A4/A7 [1,11,20,40]. Anais (1971) indicated that gynoecious lines of cucumber could be maintained by grafting onto various cucurbit stocks [1]. It has been found that large numbers of staminate flowers on gynecious genotypes cucumber was induced when treated with both silver nitrate and aminoethoxy-vinylglycine [3,5,12,37,39,55]. Auxins and chemicals were widely used to induce the formation of male flowers, female flowers and perfect flowers and to change the sex expression of cucumber and melon, however how about the effect of these chemicals to influence the flowering of coba is still needed for further studies.

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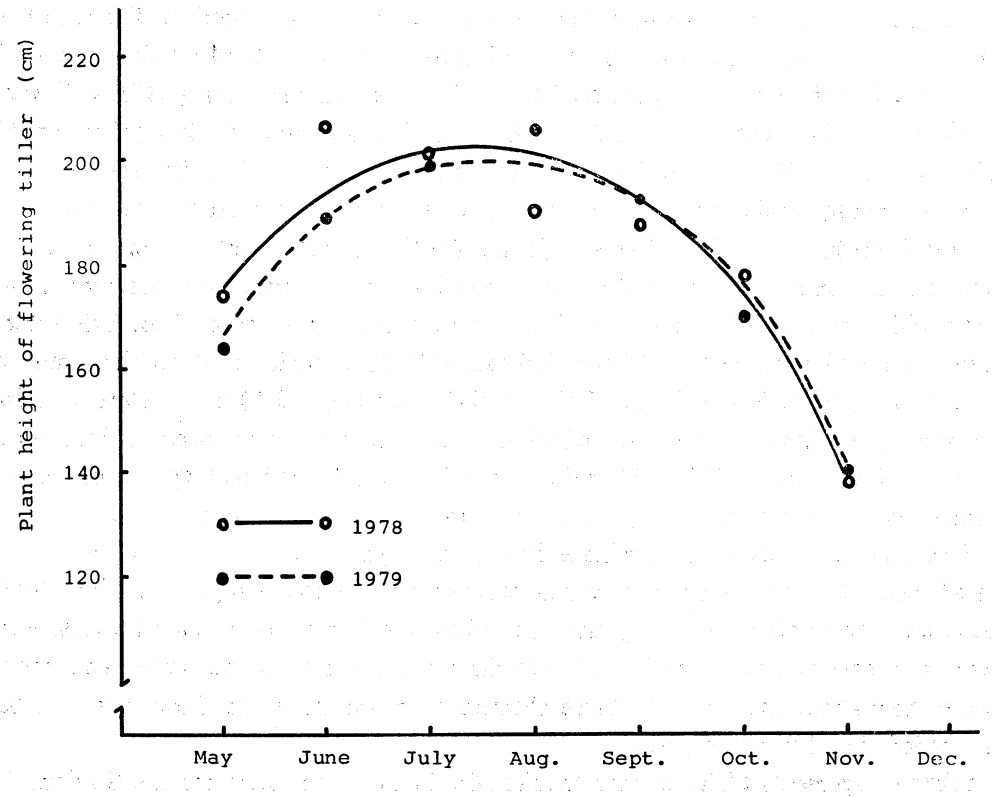


Fig. 1. Monthly variation in plant height of flowering tillers of coba (*Zizania latifolia* Turcz.) in 1978 and 1979.

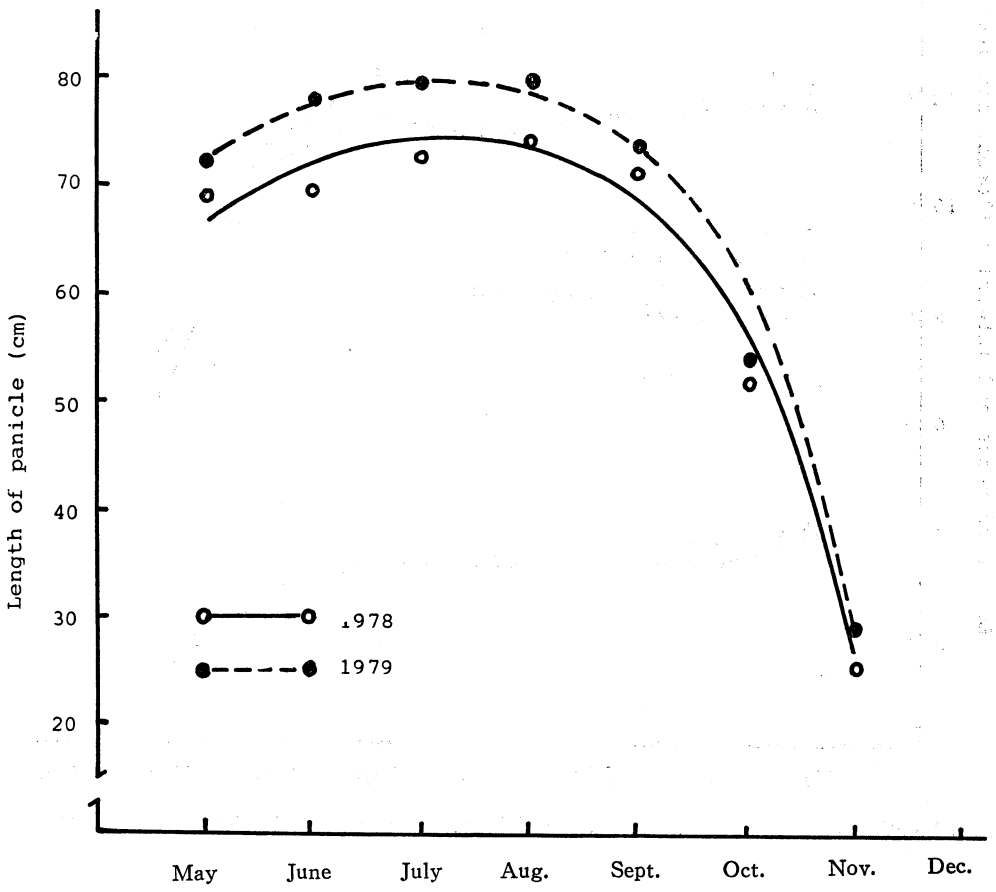


Fig. 2. Monthly variation in length of panicle of coba in 1978 and 1979.

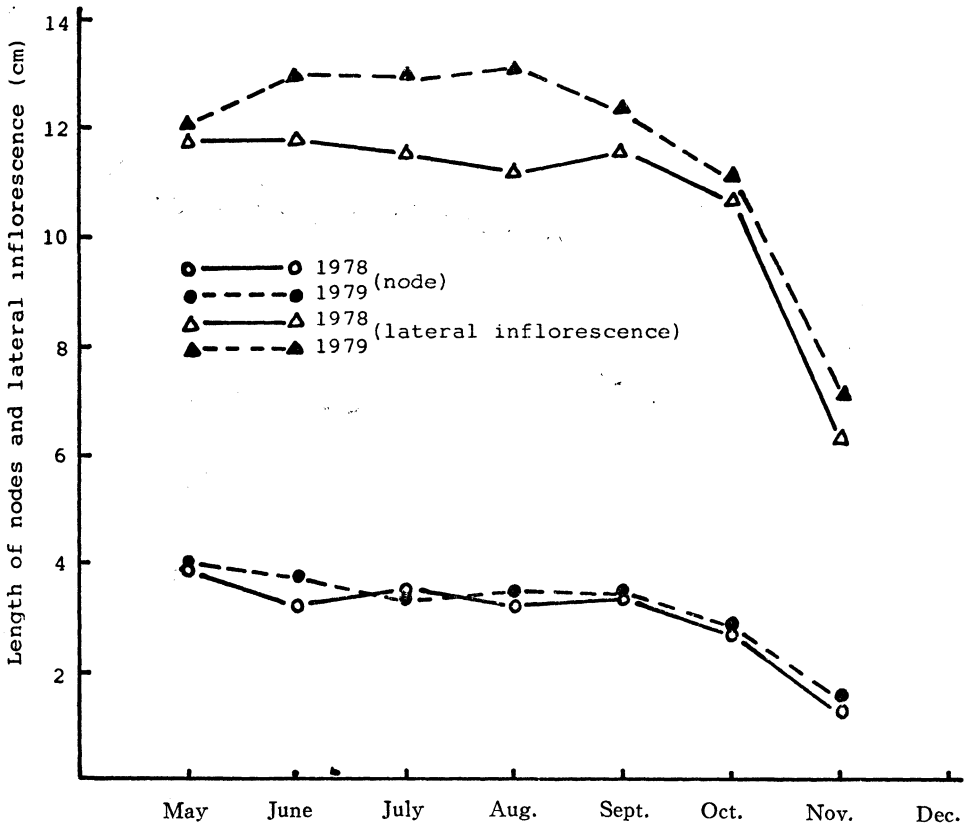


Fig. 3. Monthly variation in length of node and lateral inflorescence of coba in 1978 and 1979.

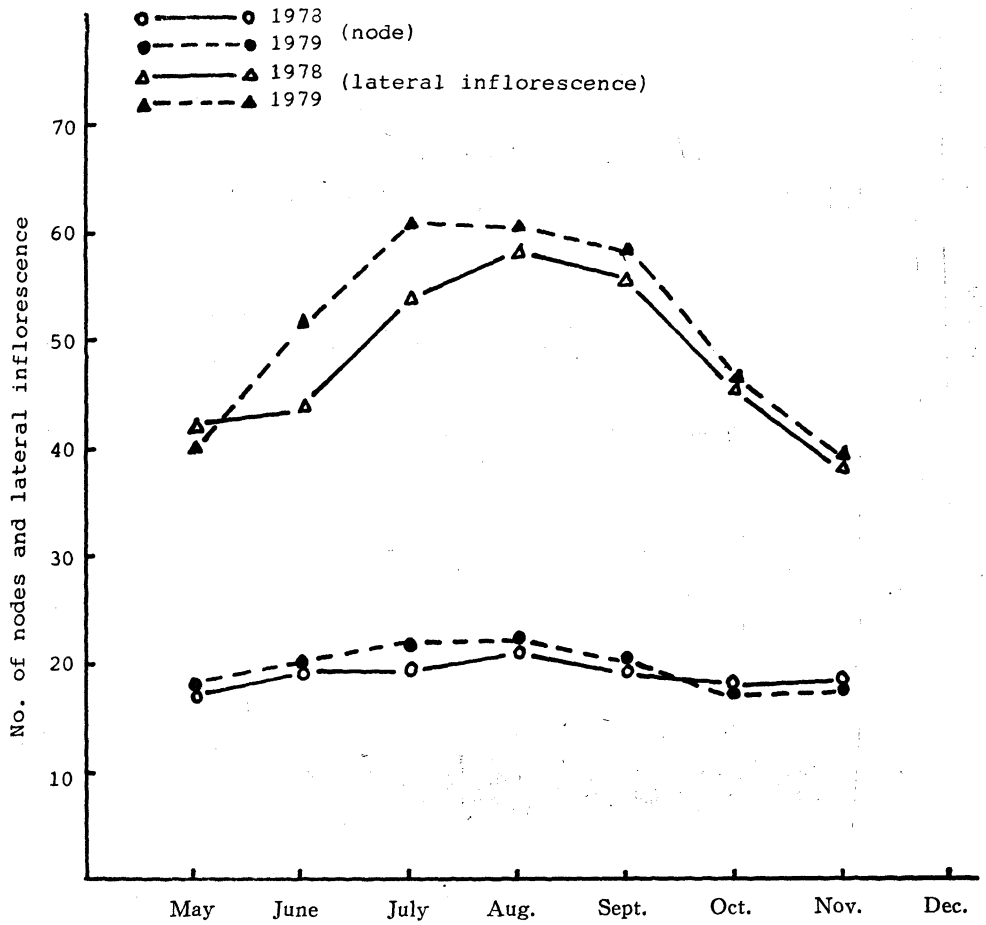
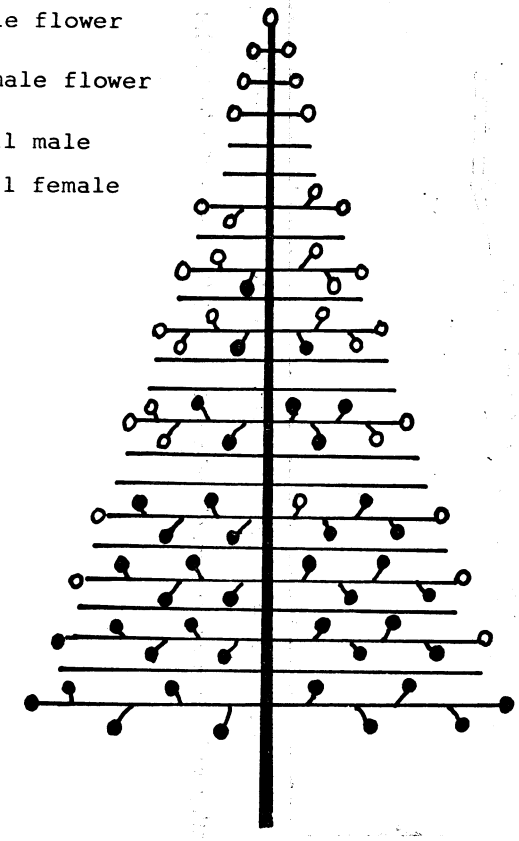


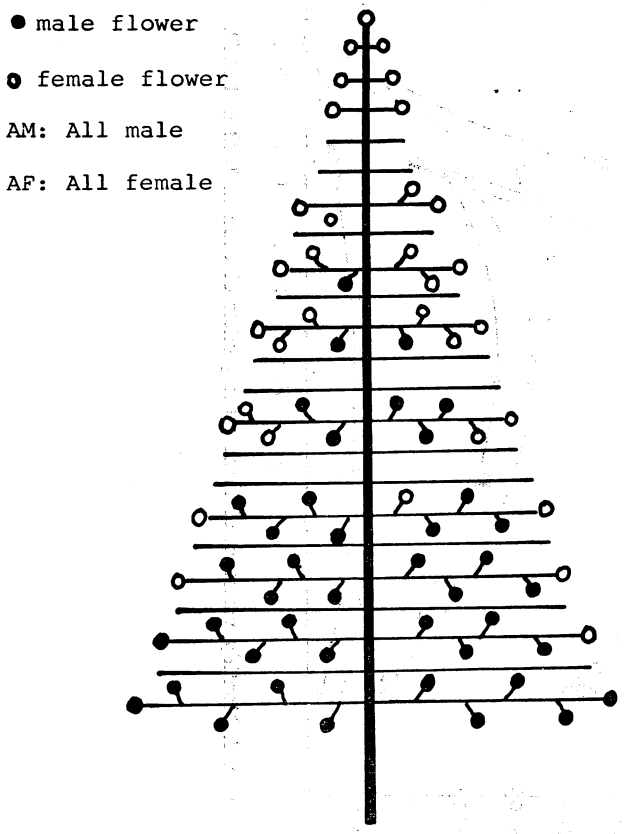
Fig. 4. Monthly variation in average no. of nodes and lateral inflorescence of coba in 1978 and 1979.



Sex ratio male/female = X*/1

May	June	July	Aug.	Sept.	Oct.	Nov.
			AF			
			AF			
	AF	AF	AF	AF		
	AF	AF	AF	AF		AF
	AF	AF	AF	AF	AF	AF
AF	AF	AF	0.1	AF	AF	AF
AF	AF	AF	0.3	AF	AF	AF
AF	AF	0.1	0.3	0.1	AF	AF
AF	0.1	0.2	0.4	0.2	AF	AF
0.2*	0.3	0.2	0.4	0.2	0.1	AF
0.4	0.5	0.7	0.6	0.4	0.1	AF
0.9	0.7	1.0	0.9	0.6	0.2	AF
0.7	1.0	1.1	1.1	1.0	0.3	AF
1.1	1.2	1.2	1.2	1.1	0.3	AF
1.7	1.6	1.4	1.4	1.0	0.5	AF
2.4	2.2	1.9	1.8	1.3	0.7	AF
3.2	2.9	2.0	1.8	1.5	0.8	AF
4.5	4.1	2.1	2.8	1.9	1.0	AF
5.6	4.8	2.2	3.4	2.3	1.0	AF
8.7	7.5	3.2	5.1	5.2	1.7	AF
20.1	20.8	5.3	6.1	7.4	2.0	AF
61.0	AM	51.0	58.1	AM	1.5	AF

Fig. 5. Monthly variation of male and female flowers distribution pattern and sex ratio in the inflorescence of coba in 1978.



Sex ratio male/female = X* / 1

May	June	July	Aug.	Sept.	Oct.	Nov.
		AF	AF			
		AF	AF			
	AF	AF	AF	AF		
	AF	AF	AF	AF		AF
	AF	AF	AF	AF	AF	AF
AF	AF	0.3	0.1	AF	AF	AF
AF	AF	0.4	0.2	AF	AF	AF
AF	AF	0.4	0.4	0.1	AF	AF
AF	AF	0.6	0.5	0.1	AF	AF
0.1*	0.1	0.8	0.8	0.3	0.1	AF
0.3	0.4	0.8	0.8	0.4	0.2	AF
0.9	0.7	1.0	1.0	0.6	0.3	AF
0.7	0.6	1.2	1.2	0.7	0.3	AF
0.9	0.8	1.3	1.2	1.0	0.3	AF
1.3	0.8	1.6	1.5	1.0	0.5	AF
2.1	1.3	1.8	1.4	1.1	0.8	AF
2.5	1.6	1.9	1.5	1.1	0.9	AF
3.9	2.7	2.0	2.1	1.6	1.0	AF
5.0	3.6	2.3	3.2	2.1	0.9	AF
7.4	6.3	3.6	5.1	3.1	1.1	AF
13.1	10.1	5.7	4.8	3.4	1 5	AF
AM	AM	38 0	37.0	AM	1.2	0.5

Fig. 6. Monthly variation of male and female flowers distribution pattern and sex ratio in the inflorescence of coba in 1979.

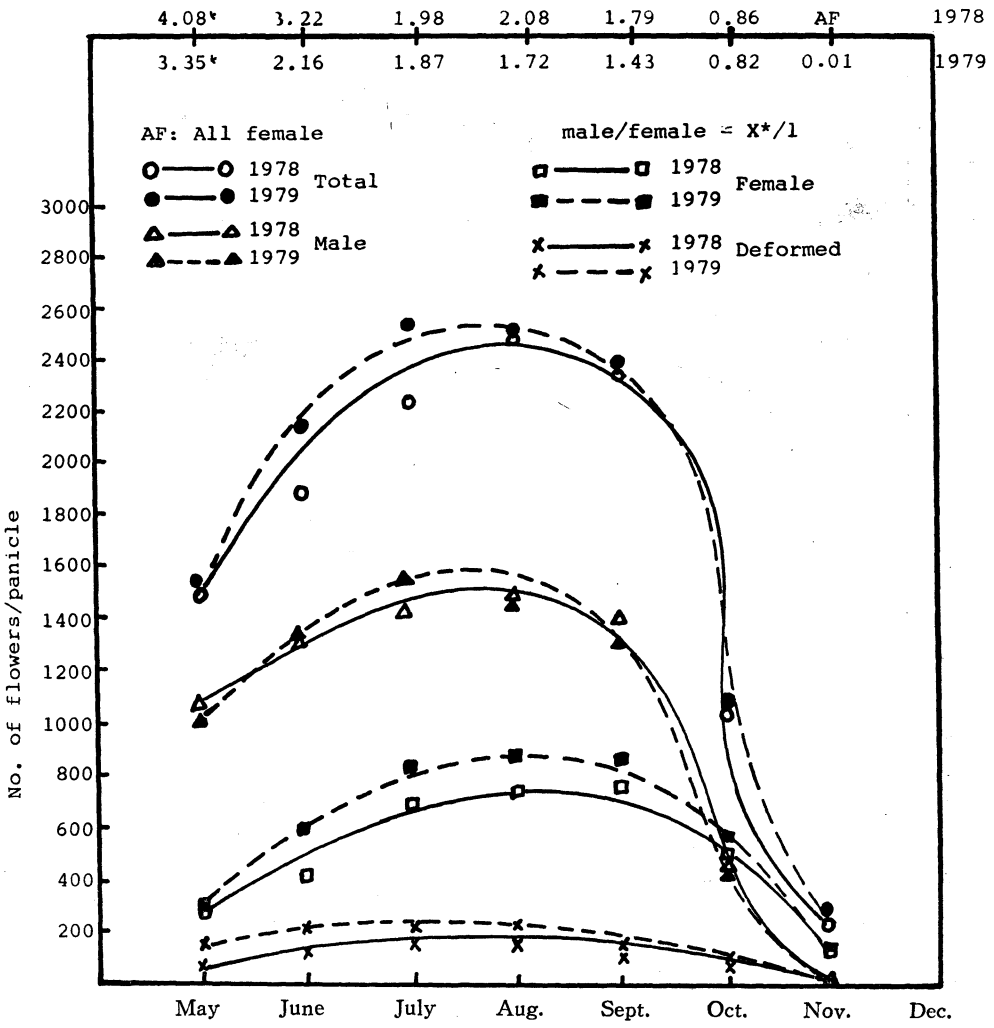


Fig. 7. Monthly variation of flowers per panicle of coba in 1978 and 1979.

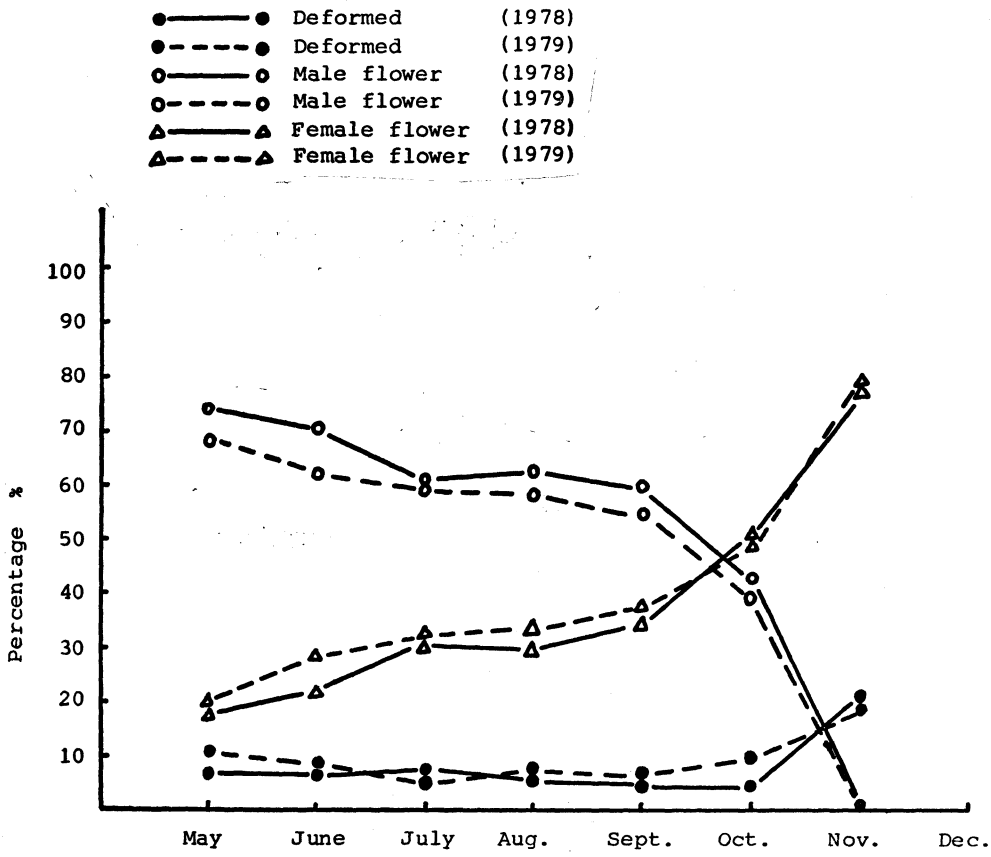


Fig. 8. Monthly variation in percentage of deformity, male and female flowers per panicle of coba in 1978 and 1979.

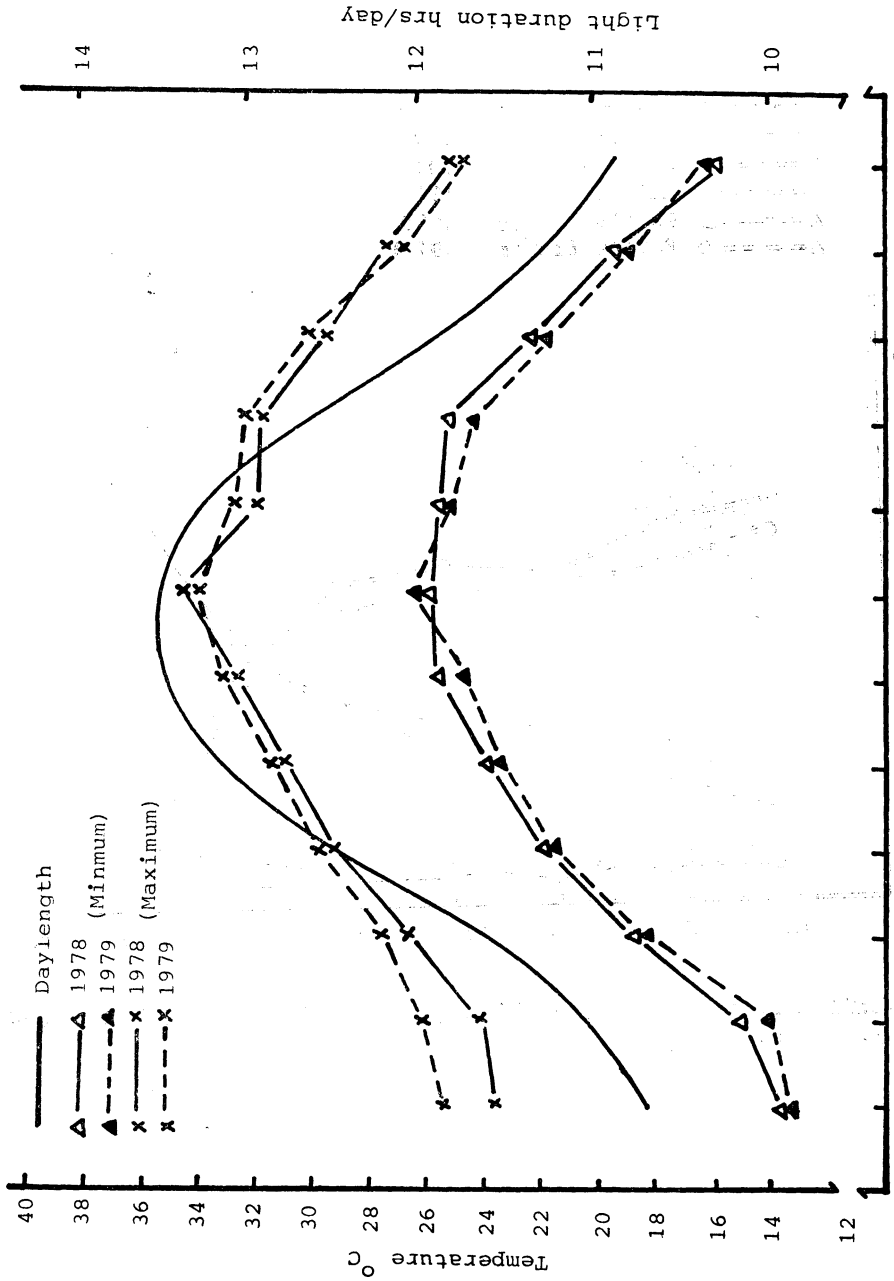


Fig. 9. Daylength variation in Kaohsiung area and monthly temperature variation in 1978 and 1979.

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季節變異對茭白花性表現之影響[1]

劉 政 道[2]

摘 要

青殼品種茭白在臺灣南部地區於5～11月間陸續抽穗開花，雌雄同株異花，雌花與雄花混生在同一花序中，花序是由多數小穗狀花序集合而成之大型圓錐花序，雄花主要着生於花序下部之小穗，雌花則以着生於上部之小穗爲主，花穗之長度、花穗節間長度、側花穗長度、側花穗數目、總花數、退化花數、雄花數、雌花數及雄花／雌花比均隨開花月份之不同發生明顯之變化，花穗長度、花穗節間長度及側花穗長度於5—9月份開花者，差異不明顯，10月份以後開花者，則明顯的下降，側花穗數目、總花數、退化花數、雄花數及雌花數均自5月份起有明顯之增加趨勢，至8或9月份最多，以後急劇下降，雄花／雌花比亦自5月份開花之最高而後逐漸減少，5月份開花者之比例約爲4：1，7月與8月份開花者之比例大致相似，約爲2：1，10月份開花者約爲1：1，至11月份開花者，花穗上極少雄花甚或完全沒有雄花着生，僅呈現雌花之現象。

1.臺灣省農業試驗所 研究報告第1081號。本文承蒙沈分所長再發，亞洲蔬菜研究及發展中心郭博士忠吉、林主任昭雄斧正，特此深致謝忱。

2.本所鳳山熱帶園藝試驗分所 助理研究員。臺灣省 高雄縣 鳳山市。